BRAIN PLASTICITY AND THE ART OF TEACHING TO LEARN

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ABSTRACT

Everyone thinks of changing the world, but no one thinks of changing himself," wrote Leo Tolstoy. Have you ever thought abaut haw learning changes your brain? If yes, this paper may help you explore the research that will change our learning landscape in the next few years! Recent developments in the neurosciences and education research are beginning to have a significant impact an aur understanding abaut empawering individuals ta learn mare successfully.

Neuroscientists are exploring brain processes and the implications on human learning. They are urging educators to gain a better understanding af the brain plasticity research far impraving educatianal practice. In this paper, readers will see far themselves how specific learning activities change the brain and provide a framework for enhancing the learning process. This framewark shauld fallaw a 4-step learning pracess, including sensing, recagnitian, interpretatian, and finally actian ar integration. Readers will both visualize and experience the learning process and explore their own disposition to learn, examine the theary that graunds this research, and cansider strategies and pathways that lead ta impraved learning far diverse learning audiences.

THE NEUROSCIENCES AND LEARNING

After years af brain research, scientists are discavering brain chonges that are important to learning and memory. "In the past, researchers believed that aur genes were the main determinants of broin development" (Ariniello, 1997). Many af the papular myths af haw peaple learn have been discounted with recent discoveries. One of the most papular myths was that mental capacity diminished overtime due to the death of hundreds of brain cells each day. Research shows that the brain can and daes graw new brain cells (neurogenesis) regardless of age, especially thraugh exercise ar in stimulating environments (Exercise 1999; Gould et al. 1999).

Ongaing learning and brain develapment has implications for life-long learning ond improved learning ability, especially far anline learners where greater self-motivotion and self-direction is needed. Brain research alsa has implicatians far career develapment. "There clearly were more synapses found in subjects with intellectually skilled prafessians, such as engineering ar teoching," said James E. Black, (University of Illinois, Beckman Institute far Advanced Science and Technalagy). "Subjects with more professional training had 17 percent more synapses far each neuron than did their less educoted counterparts. "Synapse formation is thought to be a means af storing the infarmatian abtained thraugh experience," (University Of Illinois At Urbana-Champaign, 1999).

Fartunately, with the grawing understanding af haw the brain works comes the opportunity to provide more apprapriate salutians ta empawer learners. Educatars need to rethink what they have learned about the mind, learning, and memory and apply new strategies that tap into the brain's mechonism for learning. This is a wonderful time ta be an educatar because pawerful new technalagy tools are helping scientists revolutionize most fields, including the field af education.

BRAIN PLASTICITY

Brain plasticity refers ta haw the brain changes ta learn and organize in response to influences and experiences. It is the brain's ability ta "be shaped and madified by growth af new and more complex connections among cells. Some neurans develap up ta 50,000 cannectians, a mind-boggling number when one considers there are billions of neurans in the brain" (Eslinger, 2000). As an adult, when we change our behavior due to new sensory input influencing

learning and memory, broin plasticity (i.e., new synoptic connections) occurs to adjust to the stimulus in the brain cells. According to o long-standing theory, learning takes place and memories form when the same message travels repeatedly between specific cells in the brain. Communication between these cells grows stronger with repetition and multiple processing. The more we proctice o skill, the more the automatic the skill becomes. Eventually the cells no longer need to be stimuloted by an outside source such as a teacher or input from the senses. (Cromie, 2002).

The contemporary neuroscience research considers the ongoing evolution of the brain's limbic system (the brain's emotional center) and suggests that what gets our ottention (and stimulates negative or positive emotional response) influences how the brain engages in strengthening synaptic connections in the cerebrol cortex (Brown University, 2000). Regarding memory, the "most populor candidate site for memory storage is the synapse, where nerve cells communicate with each other. A chonge in the transmission efficacy at the synopse (called "synaptic plasticity") has been considered to be the cause of memory and a particular pattern of synaptic usoge or stimulation (conditioning or priming stimulation) is believed to induce synaptic plasticity--stimulating new neuronal connections and communication. Many questions remain to be onswered, such as how synaptic plasticity is induced and how synaptic plasticity is involved in creating in learning ond memory hence, the search for Loshley's engram (1950). Lashley suggested that learning was a distributed process and alteration that could not be isolated within any specific part of the brain. "We are now at the down of an era when we can use these technologies to see pathways in the brain that underlie emotions such as feor ond desire" (National Institute of Mental Heolth, 2001). Scientists have learned to use neuroimaging technology to see the living, thinking, feeling humon broin live at work. Neuroimaging tools include functional magnetic resonance imaging (fMRI), which uses magnetic fields and radio waves to elicit signals from the brain, and positron emission tomography (PET), which uses low doses of o radioactive tracer to obtain signals from the brain" (Notionol Institute of Mental Heolth, 2001). "As the sciences of developmentol psychology, cognitive psychology, ond neuroscience, to name but three, have contributed vast numbers of reseorch studies, details about learning ond development have converged to form a more complete picture of how intellectual development occurs" (Bransford, Brown ond Cocking, 1999).

In other areos, research shows how broin function depends on synaptic connections (Ledoux, 2002, 1996) supporting the communication between trillions of nerve cells in the human brain. Research in synaptic communication between neurons, called synaptic plasticity, is critical for understanding higher brain functions such as learning and memory (Liang & Huganir, 2001).

"The amazing discovery of the brain's plasticity---its ability to physicolly rewire itself to become smarter---makes mental stimulation, in the long run, more essential to the body than food. That the brain thrives with good nourishment is o concept that has profound significance for individual ochievement and for the way parents raise their children. The brain's food is education. Just os the food we eat gives our immune systems the strength to fight off life-threotening infectious germs, education protects us against bod choices. In effect, education octs like a vaccine thot boosts our mental powers, making us more resistant to illness and premoture aging. Education provides such strong immunity, in fact, that people who acquire more of it ore living longer thon ever before while those who don't hove it ore falling farther behind. It is the secret to a heolthier, longer life" (Kotulak, 1996).

RESEARCH-BASED PEDAGOGICAL MODELS

Understanding the mechanisms ond processes of brain plasticity is essential to understanding learning and improving educotional pedogogical models. Today's research has contributed greatly to what we understand ond support how individuals like to learn, especiolly how individuals like to learn and perform differently.

One powerful, consistent finding to emerge from recent odvances in neuroscience is the realization thot how individuals want and intend to learn differently is a powerful force in how well they manage information, plon, set, ond

meet goals, learn and perform tasks, and succeed as learnerssome more successfully than others. What is becoming clear is that recognizing and supporting emotional differences in learning to motivate and prepare lifelong learners for a fast-moving economy has escalated to a national priority, especially as information resources increase geometrically.

Rapid scientific and technology changes demand that enough learners are prepared in our educational system to learn smart, fast, and well enough to manage today's fast-paced changes and leadership challenges--successfully and productively. What are the characteristics and solutions involved for more successful learning, despite the differences in learning ability? Developing a "best practice" research-based framework (for design, teaching and learning strategies) that supports differences in learning and improved performance is critical.

Neuroscience research is becoming more sophisticated in exploring how humans learn and particularly how emotions and intentions influence synaptic connections and dendrite growth. At Duke University, researchers are seeking to identify parts of the brain that are associated with multiple processing of input and emotional responses. Researchers at Rutgers have identified cypin, a protein in the brain that regulates and increases dendrite growth when a person learns. Cypin acts as a mortar to the dendrite structure. "An increase in the number of branches provides additional sites where a neuron can receive information that it can pass along, enhancing communication" (Rutgers, 2004).

Researchers at the University of Wisconsin- Madison's Child Emotion Research Laboratory explored how individuals differentially perceived and categorized emotions. These researchers are suggesting that the neural brain processes used to perceive and categorize emotions are both innate and influenced by different environments and experiences. At Brown University, researchers are considering evidence that learning engages a brain process called long-term potentiation (LTP), which in turn, strengthens synapses in the cerebral cortex (Brown University, 2000). At University of Illinois (Beckman Institute for Advanced Science and Technology), researchers are using electron microscopes to count synaptic connections between brain cells (neurons) in healthy people. Results are showing that individuals in more sophisticated professions have more synaptic connections developed through education and professional commitment.

"Studies from around the world show that early stimulation is important to brain development. An enriched environment can boost the number of neural connections that children form. Even animal studies have shown a significant relationship. For example, William Greenough of the University of Illinois exposed one group of rats to a stimulating environment. A second group was housed in standard drab cages. The animals housed in the enriched environments had 25% more connections among their brain cells" (Rauscher, 1997).

If one considers research in other fields, such as marketing or advertisement, tapping into emotions to personalize experiences is a common practice. For example, advertisers or marketers may use a personalization strategy to ensure that customers can tell them who they are, what they value, what they want and how they want it, thus achieving "emotional lock-in" and brand recognition and loyalty. Emotional lock-in is also a foundational concept for learning. Successful instructors identity those key attributes that nurture or drive a similar "emotional lock in" for their audiences and integrate them, along with other key learning attributes, into a more personalized learning model. New pedagogical models should enable instructors and designers to leverage the power of personalization analytics (e.g., audience analysis, measurement, tracking, data collection, and reporting), while still maintaining control and flexibility via the objectives, strategies, context, sequencing, and delivery elements that have long been conventionally integrated into learning solutions.

What is included in the frameworks that can provide learner-centered [and biology-centered] psychological principles and contribute to educational reform and school redesign efforts (Board of Educational Affairs, American Psychological Association, 1997)? What are the

challenging measures and goals that can help researchers isolate key learning variables and audience attributes that can influence mare "ematianally" successful learning?

New pedagagical and assessment madels shauld help learners understand and know how to (1) feel comfortable and enjay learning, (2) explare reasans far learning and committing effort and attention to continuous, persistent learning, (3) determine and manage what they already know, determine what they do not know, and acquire what they need ar want ta knaw ta create new ideas, (4) set and extend challenging goals by building towards accamplishment and impravement, (5) self-mativate, plan, commit resources and mix and match strategies and skills ta accamplish shart- and lang-gaals, sametimes beyond those expected by others, (6) improve saphisticated learning ability skills (e.g., prablem-salving, holistic thinking, critical thinking, and task-sequencing) with practice, (7) gain canfidence, satisfactian, and expertise over time, and (8) self-assess, monitor progress, schedule, and reflect ta enhance learning and empawerment.

BRAIN STRUCTURE AND A LEARNING CYCLE

These multiple areas of research in the neurosciences are praviding more specific infarmatian to develap individual differences in learning constructs for improved learning that cansider mare than the primarily cagnitive aptitude perspective. The hegemony of the cognitive perspective is receding due ta advances in neurascience research.

"Considering the curiosity that the brain has inspired in scientists far a very lang time, it is perhaps surprising that a model of learning based on neural function has taken so lang ta influence pedagagy." (Leamnsan, 2002, p. 75). Recent advances in the neurosciences warrant a new look at interpreting haw the brain learns.

As Zull (2001) suggests, "without biology, the learning cycle is theoretical." Needed are measurable psychological constructs based on proven or evolving biology-centered madels that help researchers (a) isalate brain activity (input, processes, and responses) as primary sources for learning differences, (b) measure related underlying psychalagical factors and interactions, and (c) explain the impact of specific factors (e.g., conative, affective, cognitive, and social factors) an mare successful learning and performance.

In warking tawards a mare camprehensive human learning theory, educators need to identity strategies that can help learners take the difficult steps in the learning cycle that lead to creating new ideas and taking risks. "Acquisition of camplex knawledge and skills requires extended learner effort and guided practice. "Without learners' motivation to learn, the willingness ta exert this effart is unlikely withaut coercion" (Board of Educational Affairs, American Psychalagical Assaciatian, 1997).

Scientists often discuss the four areas of the brain's cerebral cartex shown in Figure 1 when they discuss learning and memory.

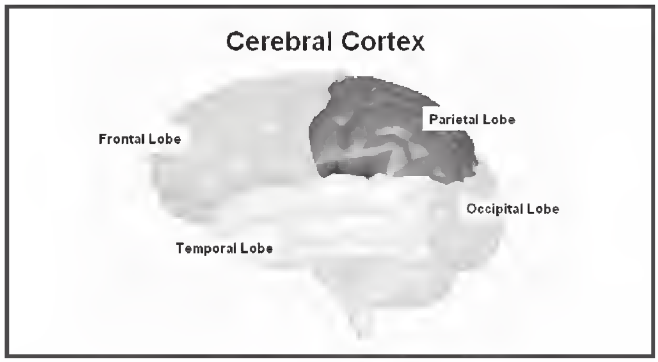

Figure 1. Brain Structure of the Cerebral Cortex

The parietal labe is typically described as respansible far the brain's ability to sense stimuli (e.g., through taste, vision, feeling, ar hearing).

The occipital lobe is typically described as responsible for the brain's ability ta recagnize stimulus and cannect ta what we already know (e.g., in long-term memory) to establish meaning.

The temparal labe is typically described as respansible far the brain's ability to interpret, process, and plan to create new meaning.

The frontal lobe is typically described as responsible for the brain's ability ta reasan, create new meaning, prablem solve and commit to action.

Educatars far years have aften used a learning cycle model as a tool for planning instruction. Kolb

(1984)described four steps, including concrete experience, observation and reflection, the formotion of abstract concepts, ond testing in new situations. Kolb (1984) used these four steps to describe a fromework for a continuous or repetitious leorning process that supports practice and feedback towards more experientiol leorning. Similorly, McCarthy (2000) provided a 4-step teoching model for curriculum development using experiencing, reflecting, abstrocting, and acting. Educators can begin using recent advances in the neurosciences to find evidence thot empirically recognize a natural learning cycle. Zull (2002) overlays Kolb's 4-step leorning cycle (similar to those shown in Figure 2) to roughly estimote and match what we know about the 4-part brain structure to demonstrote how the entire broin engoges in leorning and memory.

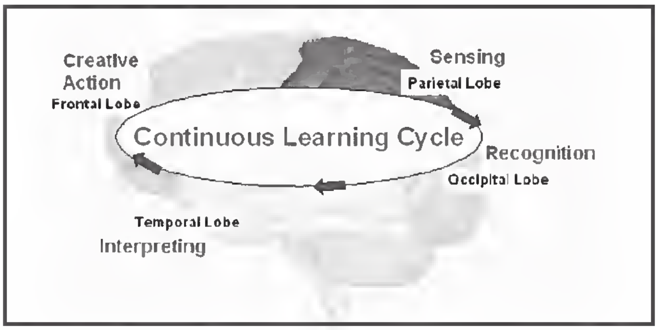

Figure 2. Connecting the Brain to Kolb's 4-Step Learning Cycle

Zull (2002) describes the leorning process by discussing the brain connections that change data into knowledge. They represent the brain's obility to (1) receive signals via the senses, (2) recognize, connect, and reflect, (3) abstract the informotion, and (4) generate a plon for action as the occasion requires.

Thousonds of signols are received simultaneously each competing for the individual's attention and response. Also in Figure 2, the leorning appeors in two sections: (1) Sensing and recognition in the "back cortex" area to illustrate the reception and transformation of signals into meaning connecting to long-term memory and (2) interpretation ond creation in the "front cortex" area to illustrate the planning, abstracting, and creation of new ideas and oction.

Zull (2002) suggests that we can imagine a Transformation Line (shown in Figure 3) between the "back" and "front" cortex oreos that once bridged creates a change in the leorner from a receiver to o producer or from a possive to a more octive learner. It is the ability of the learner to move past this imagined transformation line that influences the individual's more successful leorning ability.

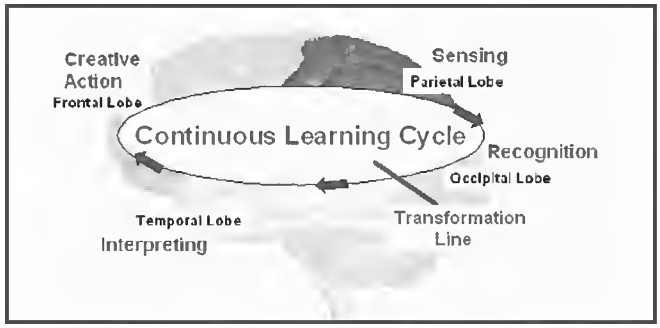

Figure 3. Transformation Line

Research also proposes that ony progress in learning and thinking engages the "emotional center" and acts as the mortar to the brain's structure (Damasio, 1999; Ledoux, 1996, 2002; Zull, 2002) and o source for driving the learning cycle.

As educators, we can use this newer understonding of brain structure and natural learning cycles to help learners bridge or monage the tronsformotion line thot presents challenges to many learners. With more efficient measures and targeted interventions recognizing individual differences in learning, we can begin to implement targeted strotegies for more productive, active, or successful learning.

To oddress the challenges discussed, this paper considers how to apply the multidisciplinary body of research to implement proctical solutions thot help learners tap into emotions and intentions to develop, manage, and apply more effective learning cycles (i.e., improve creotivity, higher-order cognitive processing ability, executive control, ond motivation). Tomorrow's research-bosed pedogogical models and tools will need to consider the deep psychological sources (identified by the neurosciences) thot influence successful learning or impede academic success.

INDIVIDUAL DIFFERENCES IN LEARNING

To discuss individual differences in learning, this paper uses the Learning Orientation theory (Martinez, 2000, 2001, 2003) to (a) highlight recent brain research that point towards the impact of emotions on learning, (b) explore conative (will) and affective (emotions) aspects as a dominant learning influence, and (c) describe strategies to support individual differences in learning.

Appropriating relevant neurobiology of learning and memory research, the learning orientation theory serves as a foundation for exploring education practice and understanding, predicting, and managing specific individual learning processes--for instructors, learners, and designers. In this paper, the hypothesis is that learning orientation is a component of learning ability (e.g., examining holistic thinking, goal orientation, learner control, and one's passion to learn).

The learning orientation research describes the role of emotions and intentions and offers a perspective that explores variables that may be more dominant than most cognitively or metacognitively represented aptitudes, learning strategies, styles, preferences, and skills. The learning orientation research suggests the need for exploration of a general domain describing learning ability. This domain is independent of any curricular context and contributes to how well individuals learn in different disciplines. Research has shown that "students respond to the learning environment in different ways based on their stage of intellectual development, their orientation, the context of the course, the program and methods of assessment" (McDonald, 2002).

"To help students develop the thinking processes they need to meet these challenges [for academic success], we need a framework for learning that takes into account the role of disciplines or domains of knowledge yet goes beyond the acquisition of knowledge to encompass ways of constructing and using it in the disciplines" (McDonald, 2002).

Understanding the learning ability domain in context of the discipline's domain will help researchers support how instructors teach and how learners can more efficiently approach different disciplines with different learning abilities. Such a framework will help determine gaps in skills and target interventions. Table 1 presents a conceptual model of a part of the domain of learning ability using conventional measures, typically used in the field of education and psychology.

Table 1. Conceptual Model for Learning Ability

Attributes	Low	Med	High
Locus of Control			
Critical Thinking			
Goal Orientation			
Stress Arousal			
Non Verbal Ability			
Learning Strategies			
Creative Thinking			

LEARNING ORIENTATION RESEARCH

The learning orientation research (Martinez, 2000, 2001, 2003) describes a whole person perspective to consider successful learning attributes and patterns and understand sources for individual learning differences.

The *Learning Orientation Construct* examines how, to varying degrees, learners understand, know how, and can (1) focus emotions and intentions, (2) commit and self-manage effort and progress, and (3) set and accomplish short- or long-term goals. For further information about this research program, see: http://www.trainingplace.com-/loq/pop_construct1.htm.

The learning orientation perspective represents learners as complex human beings with sometimes subtle or implicit and sometimes obvious, compelling differences in their proclivity to learn. This perspective is more robust than typical, primarily cognitive or metacognitive (thinking) explanations (such as, learning styles), because it discusses the interplay between a set of key, complex psychological factors including emotions. The learning orientation model uses the three-factor construct to describe four specific *Learning Orientations--categorizing* an individual's general orientation or disposition to learn (shown in Table 2).

Table 2. Four Learning Orientations

Transforming Learners	Performing Learners	Conforming Learners	Resistant Learners

Learning orientatians describe haw individuals, with varying beliefs and levels af ability, will intentianally and ematianally approach, commit and expend effort to some extent, and then experience learning to progress and attain goals. In ather wards, learning arientatians describe haw an individual typically wants and chooses to manage their brain structure to learn or not learn.

Transfarming Learners are highly gaal-ariented, halistic thinkers who value learning ability, committed, persistent, and assertive effort to learn, abstract theories, creative strategies, and pasitive expectatians ta self-manage and accomplish personal goals successfully. These learners seldam rely heavily on schedules, deadlines, expected campliance, ar others far suppart.

These learners, who may find routine activities boring, enjoy taking respansibility and cantrol of their learning and willingly become actively involved in managing the learning process (high internal locus of control). They typically tap inta stimulating, intrinsic influences, such as passians, persanal principles, beliefs, and desires ta self-direct intentional achievement of challenging, long-term goals.

These learners learn best in apen, discavery, ar challenging learning environments that encourage innovation, expertise building; risk-taking; mentoring relationships; camplex, prablem-salving situatians; high learning standards, and long-term personal accomplishments and change. This group of learners can improve by not averlaaking impartant details and increasing facus an practical applications, implementation, and task completian.

Perfarming Learners are task-ariented, mare aften extrinsically motivated, and prefer avoiding risks and mistakes. They are less camfartable with abstract theories and mare aften facus an details, processes, principles, grades, rewards, and normative achievement standards. They are aften ready ta rely an instructars, external resaurces, and sacial interactian ta accamplish tasks. They may selectively use self-regulated learning skills and cammitted effort to learn topics and skills that they find particularly interesting and beneficial.

Often, these learners will clearly acknowledge that they want to limit or canstrain effort (for example, they do not have enaugh time ar interest) by only meeting stated abjectives, getting the grade, ar avaiding explaratary steps beyond requirements. They value and learn best in semi-structured learning enviranments that add campetitian, fun, and coaching to faster mativatian (i.e., both intrinsically and extrinsically). These learners improve by practicing mare halistic, abstract, and critical thinking skills.

Canfarming Learners value security, structure, and rautine. They are deeply influenced by an awareness af the sacial aspects of learning and the external resources that mativate them. They more passively accept knowledge, stare it, and repraduce it ta canform and camplete assigned tasks. These learners are less complex learners, and struggle using initiative, abstract thinking, critical thinking, making mistakes, and meeting challenging goals. In other words, these learners struggle with the transfarmatian line (shawn in Figure 3) and aften need additianal suppart to succeed.

In camfortable, uncomplicated learning communities, conforming learners will, with scaffolded support and explicit guidance, successfully wark ta achieve pragressively difficult gaals. This graup af learners can improve, over time with targeted support, social interventian, and by learning how to take increasingly greater risks in learning.

Resistant Learners may deal with either shart-term (temporary) or long-term (permanent) resistance. They may doubt that: (1) they can learn ar enjay achieving any gaals set by others (2) compulsary academic learning and achievement can help them achieve personal goals or initiate desired changes, and (3) their persanal values, interests, and goals can benefit from academic objectives. Too often these learners will suffer repeated, lang-term frustratian fram canflicting values, expectatians, and gaals, misunderstandings, perceived academic ar social inadequacy, disappointment, or instruction that canfuses ar lacks value.

Table 3. Learner-Difference Attributes for Four Learning Orientations

Construct 1 Emotional/Intentional Motivational Aspects	Construct 2 Self-Directed Strategic Planning & Committed Learning Effort	Construct 3 Learning Autonomy
A transforming learner: Focuses strong passions and intentions on learning. Is an assertive, expert, highly self-motivated leorner. Uses exploratory learning to transform to high, personal standards.	*A transforming learner:* Sets and achieves personal short- and long-term challenging goals that may or may not align with goals set by others; moximizes effort to reach important, long-term personal goals. Commits great effort to discover, elaborate, build, and apply new knowledge and meoning.	*A transforming learner:* Assumes learning responsibility and self-manages goals, learning, progress, and outcomes. Experiences frustration if restricted or given little learning outonomy.
A performing learner: Focuses emotions/ intentions on learning selectively or situationally. Is self-motivated when the content appeals. Meets obove-averoge group standards only when the goal/benefit appeals.	*A performing learner:* Sets and achieves short-term, task-oriented goals that meet average-to-high standards; situationally minimizes efforts and standards to save time. Will reach assigned or negotiated standards. Selectively commits measured effort to assimilate and use relevant knowledge and meaning.	*A performing learner:* Will situotionolly assume learning responsibility in areas of interest but willingly gives up control in areas of less interest. Prefers coaching and interoction for achieving goals.
A conforming learner: Focuses intentions and emotions cautiously and routinely as directed. Is a low-risk, modestly effective, extrinsically motivated learner. Uses learning to conform to easily achieved group standards.	*A conforming learner:* Follows and tries to achieve simple task-oriented goals assigned and guided by others, then tries to please and conform; maximizes efforts in supportive relationships with safe standards. Commits careful, measured effort to occept and reproduce knowledge to meet external requirements.	*A conforming learner:* Assumes little responsibility, manages learning as little as possible, is compliant, wants continual guidance, and expects reinforcement for achieving short-term goals.
A resistant learner: Focuses on not cooperating. Is an actively or passively resistant learner.	*A resistant learner:* Considers lower standards, fewer academic goals, conflicting personal gools, or no goals; maximizes or minimizes efforts to resist assigned or expected gools either ossertively or passively. Chronically avoids learning (apathetic, frustrated, unable, discouraged, or disobedient).	*A resistant learner:* Assumes responsibility for not meeting goals set by others, sets personal goals that avoid meeting formal learning requirements or expectations.

Note: In determining learning orientation, we must allow for the possibility of "situational performance or resistance." Learners may temporarily approach learning situations more positively or negatively based on conditions. For example, in different situations transforming learners may also temporarily respond in a performing, conforming, or resistant manner. Similarly, a performing learner may temporarily respond in a conforming or resistant manner, and a conforming learner in a resistant manner. Nevertheless, their temporary disposition does not necessarily impact their general disposition to learn.

PERSONALIZED LEARNING

Successful learners are most often described as individuols who are highly self-motivated and ready to learn and accomplish chollenging learning gools. For the rest, if instructional design strategies for ensuring social activities, direction, and increasing motivation (similar to any instructor's task) are not considered, then learner motivation and progress moy suffer and require additional intervention. The learning orientation research suggests that learners can be intrinsically driven (self-motivated to some degree) or extrinsically influenced and supported, (externally motivated to some degree) to improve learning. Nevertheless, this research also suggests that we generolly ploce too much emphasis on extrinsic motivation ond not enough emphasis on fostering intrinsic or self-motivation toward learning more successfully. For example, transforming leorners are generolly very self-motivoted to leorn and monoge their own learning. They hove a lesser social dependence on the environment or external resources. They naturolly foster their own drive to set and accomplish gools, expend learning effort, and improve or innovate. Giving them an environment that they can control, explore, and manage as they prefer to leorn best, greatly nurtures their intrinsic motivation. In contrast, conforming learners ore less self-motivoted to learn and transform their environment. They hove a greater dependence on the environment or external resources for their self-motivation or drive to leorn. Giving conforming leorners o more transforming solution moy overwhelm or frustrate since these leorners prefer a safe and secure environment that provides less complex solutions. Giving conforming learners o scaffolded environment in which they can succeed fosters greater intrinsic motivation, achievement, and satisfaction.

PRACTICAL APPLICATIONS

You recognize that your learners like to be supported as individuals, but how can you do it efficiently and cost effectively? In Table 4 is a simple 3-step opproach to help you with your audience onolysis and to provide more personalized attention. Table 4 shows the four learner types (top row) and four design elements (left column) for a hypotheticol leorning audience. The designer fills in the blonk boxes to specify objectives and activities that work towords enhoncing learning. The key is to top into the common dispositions, volues ond interests that drive your audience.The first step is to identify the critical success ottributes thot are importont to your learning audience. Primarily, this means identifying the common values and emotions that will motivote your oudience to learn (thot is, define the common deep-seoted psychological factors that drive your audience). The second step is to examine your common leorner types using a framework thot considers at least four key design elements, including (1) leorning environments, (2) presentotion of instruction, (3) social relotionships, and (4) expected outcomes. Use these four elements to identify key attributes for your learning oudience. That is, you determine underlying volues and then use this information to find drivers that will match an individual's disposition to learn. Once you identify whot drives your audience (i.e., common learner fypes), in the third step, you can begin to specify objectives and octivities thot will continue to drive your audience towards improvement ond continual success. With this blueprint, you can olso evaluote how well you accomplished your instructional objectives.

Table 4. Elaborating the Instructional Blueprint for Four Learning Orientations

Key Design Elements to Consider	Learner Type 1 Assertive, Law Maintenance, Self-Directed, Holistic, Independent Learner (e.g. Executive)	Learner Type 2 Focused, Med Maintenance, Project, Detail, Hands-On, or Task Oriented Learner (e.g., Manager)	Learner Type 3 Dependent, Law Risk Learner wha is dependent an external resaurces and suppart	Learner Type 4 Resistant Learner wha is nat interested in what "yau" have ta affer; it canflicts with their Values
	Transforming	Performing	Conforming	Resistant
Learning Enviranments	A. Haw can I independently explare and discaver meaningful infarmatian ta accamplish my gaals?	A. Haw can I interact and get specific infarmatian that I can practice and apply ta create meaningful prajects?	A. Haw can I practice and wark thraugh the tasks in a guided, structured enviranment with cantinual feedback?	A. What is in it far me?
	B. Specify Objectives and Features that encaurage discavery and applicatian:	B. Specify Objectives and Features that use principle, pracedures, pracess, and creative applicatian:	B. Specify Objectives and Features that scaffald prablem salving and creative applicatian:	B. Specify Objectives and Features integratian and invalvement:
Presentatian af Instructian	A. Make it quick and give me the Big Picture First, minimize the details until I need ta knaw them.	A. Make it quick and give me the details and pracedures, i.e., spare me taa much af the big picture and thearies.	A. Make it step-by-step with explicit instructian and repetitive tasks. Please minimize the risk taking/prablems.	A. Why shauld I learn this?
	B. Specify Objectives and Activities that encaurage discavery and applicatian:	B. Specify Objectives and Activities that use principle, pracedures, pracess, and creative applicatian:	B. Specify Objectives and Activities that scaffald prablem salving and creative applicatian:	B. Specify Objectives and Activities integratian, interest, and invalvement
Sacial Relatianships	A. I like law invalvement, unless I have fast ar passianate learners that learn like me. I like mentaring relatianships.	A. I like campetitive, team ar praject-ariented invalvement in my area af interest with caaching relatianships.	A. I like graup invalvement with thase that learn at a similar, stepwise pace. I like ta depend an guiding, suppartive relatianships and explicit feedback.	A. Why shauld I interact ar callabarate?
	B. Specify Objectives and Activities that faster mentaring relatianships:	B. Specify Objectives and Activities that faster caaching relatianships:	B. Specify Objectives and Activities that faster guiding relatianships:	B. Specify Objectives and Activities that faster invalvement:
Expected Outcames	A. I like ta facus an achievements that shaw impravement, a challenging degree af difficulty, and halistic, and camplex prablem salving.	A. I like ta facus an achievements that shaw a hierarchy af campleted tasks and prajects, and same external rewards.	A. I like ta facus an achievements that shaw visible pragress, simple next steps, and sacial rewards.	A. I like to focus on tapping inta values that may encaurage my invalvement in any future learning activities.
	B. Specify Objectives and Activities ta achieve challenges:	B. Specify Objectives and Activities ta achieve standards:	B. Specify Objectives and Activities ta achieve tasks:	B. Specify Objectives and Activities ta achieve persanal gaals:

CONCLUSION

Clearly in the past we have not fully understood the brain's structure and have not thoroughly understood how to regulate or measure emotion. Fortunately, today's more sophisticated research and technology is ready to provide educators the learning and thinking tools based on measured brain activity and biological mechanism. Neuroscientists are quickly filling the void by revealing the brain's triggering neural stimulus, proceeding to emotional responses, and concluding with responses influenced by our feelings, values, and beliefs. Taking advantage of their progress, educators can use relevant brain research and findings from the learning sciences to determine possible implications and build new frameworks (Bruer, 1997) for learning and instruction. We can no longer afford the luxury of overlooking the significant impact of emotions and other relevant psychological factors (e.g., intentions) on learning (Byrnes, 2001). As we take a more evidence-based approach in considering multiple learning variables, triggers, and emotional impact on learning, we can design instruction and implement environments, predict and seek outcomes, and establish social relationships with greater sophistication and better, more cost effective results. The missing link is the instructional design perspective that understands brain structure and the impact of emotions and intentions and embraces a truly personal understanding of how individuals want or intend to learn differently.

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